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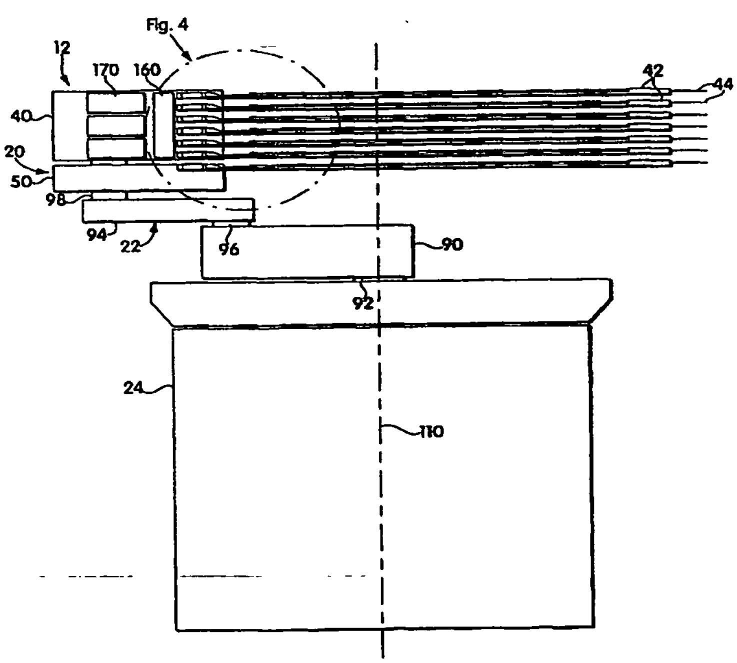
(54) Title: BATCH END EFFECTOR FOR SEMICONDUCTOR WAFER HANDLING

(57) Abstract

A wafer robot includes a first end effector and a second end effector, each having one or more wafer holders. A robot arm assembly moves the first and second end effectors to perform separate operations. A wafer carrier may be loaded or unloaded with one or more operations of the first end effector and one or more operations of the second end effector. The wafer robot may include a vacuum system for vacuum gripping of wafers on the wafer holders. The end effectors may further include vacuum sensors for sensing the presence of a wafer on each of the wafer holders.



BATCH END EFFECTOR FOR SEMICONDUCTOR WAFER HANDLING

Field of the Invention

This invention relates to apparatus for handling semiconductor wafers during fabrication of semiconductor devices and, more particularly, to batch end effectors for transferring batches of semiconductor wafers to and from wafer carriers, load locks in processing systems, and the like.

Background of the Invention

Semiconductor wafer fabrication facilities typically include a number of wafer processing systems located in a clean room. The processing systems may include ion implanters, annealers, diffusion furnaces, sputter coating systems, etching systems, and the like. Semiconductor wafers are transferred from system to system for processing in accordance with a predetermined schedule. Wafers have typically been transferred in open containers such as cassettes, either manually or using various transport systems. A minority of wafer fabrication factories have transported wafers up to 200 millimeters in diameter in closed carriers called SMIF (Standard Mechanical Interface, an industry standard from SEMI, Semiconductor Equipment Manufacturers International) boxes. These carriers contain the typically open wafer cassette accessed via a port or door in the SMIF box bottom surface. The purpose of the SMIF boxes is to isolate the wafers from particulate and gaseous contamination and to allow reduced clean room air filtration expenses.

A number of trends are apparent in the semiconductor wafer fabrication industry. Wafers are becoming larger, up to 300 millimeters in diameter, and device geometries are becoming smaller. A finished wafer may be worth as much as $250,000. Thus, extreme care is required in the handling of wafers to avoid even the slightest damage. Furthermore, as semiconductor device geometries become progressively smaller, the allowable particulate contamination specifications become more restrictive. In recent years, particulate contamination specifications have been reduced by two orders of magnitude because of the reduction in device geometries. One of the steps taken to meet the particulate contamination specifications is to store and transport wafers in enclosed wafer carriers known as front opening unified pods (FOUP's). Wafer pods typically store up to 25 wafers and have a door that is opened for access to the wafers.

Because of the need for extreme care in handling wafers and the extremely stringent particulate contamination specifications, automated wafer handling and transfer are required. Typically, wafers are removed from a wafer carrier at a processing system and are transferred into a load lock or other input port of the processing system. Following completion of processing, the wafers are removed from the system through the same or a different load lock and are replaced in the wafer carrier. The transfer of wafers to and between the wafer carrier and the processing system is typically performed by a wafer robot.

The basic components of a wafer robot include an end effector which holds one or more wafers, a robot arm connected to the end effector and a robot arm drive mechanism for moving the robot arm in accordance with signals from a controller. An example of a robot arm operation is removing one or more wafers from a wafer carrier and transferring the wafers to a load lock in a processing system. This basic operation typically involves numerous component operations, such as inserting a wafer holder into the wafer carrier between wafers, lifting a wafer from its support in the wafer carrier and withdrawing the wafer holder from the wafer carrier. Wafer robots are disclosed, for example, in U.S. Patent No. 5,607,276 issued March 4, 1997 to Muka et al; U.S. Patent No. 5,609,459 issued March 11, 1997 to Muka; U.S. Patent No. 5,664,925 issued September 9, 1997 to Muka et al; and U.S. Patent No. 5,613,821 issued March 25, 1997 to Muka et al.

A number of requirements are placed on wafer robots and their associated end effectors. The loading and unloading of wafer carriers should be completed as quickly as possible in order to facilitate high throughput and reduce fabrication cost. A batch end effector which is capable of transferring multiple wafers simultaneously may be more efficient than a single wafer end effector. However, a batch end effector that is designed for use with one wafer carrier size may be incompatible with a different wafer carrier size. Furthermore, prior art end effectors relied upon gravity and friction to maintain the wafers in fixed positions on the wafer holders. Accordingly, it was necessary to limit the speed of movement to ensure that the wafers remained in fixed positions on the wafer holders. In addition, prior art end effectors did not have the ability to sense the presence of a wafer on each wafer holder. Thus, it was not possible to detect missing wafers.

Accordingly, it is desirable to provide wafer robots and end effectors for semiconductor wafer handling which overcome one or more of the above drawbacks and disadvantages.

Summary of the Invention

According to a first aspect of the invention, a wafer robot is provided. The wafer robot comprises a batch end effector, a vacuum pump and an arm for moving the batch end effector. The batch end effector comprises a support block, a vacuum manifold, and two more wafer holders mounted to the support block. Each of the wafer holders comprises a wafer support having a vacuum opening and a vacuum channel connected between the vacuum opening and the vacuum manifold. The batch end effector further comprises vacuum sensors respectively connected to each of the vacuum channels for sensing the presence or absence of a wafer on each of the wafer holders.

The vacuum manifold is preferably located in close proximity to the wafer holders. In one embodiment, the vacuum manifold is located in the support block.

Preferably, each of the wafer holders includes an element defining a restriction in the vacuum channel for restricting gas flow from the vacuum opening to the vacuum manifold. The vacuum sensor is connected to the vacuum channel between the vacuum opening and the restriction.

The vacuum opening in each of the wafer supports is preferably located so as to engage the periphery of a wafer. In an embodiment of the invention, the vacuum opening is located so as to engage an exclusion zone of a wafer.

According to another aspect of the invention, a wafer robot is provided. The wafer robot comprises a first end effector having a first number of wafer holders and a second end effector having a second number of wafer holders, an arm assembly for moving the first and second end effectors to perform separate operations, and a controller for independently controlling operations by the first and second end effectors for loading or unloading a wafer carrier with one or more operations of the first end effector and one or more operations of the second end effector.

In a first embodiment, the arm assembly comprises a first arm for moving the first end effector and a second arm for moving the second end effector. In a second embodiment, the arm assembly comprises a single arm for moving the first and second end effectors.

Preferably, the numbers of wafer holders in the first and second end effectors are selected to permit loading and unloading of at least two different size wafer carriers with a relatively small number of operations. In one embodiment, the first end effector comprises

six wafer holders and the second end effector comprises a single wafer holder. In this embodiment, the first and second end effectors can load and unload wafer carriers having a capacity of 25 wafers with five operations and can load and unload wafer carriers having a capacity of 13 wafers with three operations.

Brief Description of the Drawings

For a better understanding of the present invention, reference is made to the accompanying drawings, which are incorporated herein by reference and in which:

FIG. 1 is a schematic diagram of a wafer robot in accordance with an embodiment of the invention;

FIG. 2 is a simplified side elevation view of a wafer robot in accordance with the invention;

FIG. 3 is a rear elevation view of the wafer robot;

FIG. 4 is a partial side elevation view of the batch end effector;

FIG. 5 is a plan view of the batch end effector; and

FIG. 6 is a schematic block diagram of the vacuum gripping and sensing system used in the end effector.

Detailed Description

A simplified schematic diagram of a wafer robot in accordance with an embodiment of the invention is shown in FIG. 1. A wafer robot 10 includes a first end effector 12 supported by a first arm 14 and a second end effector 20 supported by a second arm 22. Arms 14 and 22 are supported by a robot body 24. End effector 12 is moved by arm 14, and end effector 20 is moved by arm 22. The movement may, for example, include raising and lowering each of the end effectors and translating each of the end effectors horizontally. The arms 14 and 22 and robot body 24 are controlled by signals from a robot controller 30.

End effector 12 includes a support block and one or more wafer holders 42. The wafer holders 42 are mounted to support block 40 and are spaced to permit access to wafers in a wafer carrier. Each of the wafer holders 42 may hold a semiconductor wafer 44. The wafer holders 42 have a generally thin, flat profile so that they may be moved into the spaces between wafers in a wafer carrier. Arm 14 is attached to support block 40. End effector 20 includes a support block 50 and a wafer holder 52 mounted to support block 50. Arm 22 is attached to support block 50.

In the example of FIG. 1, end effector 12 includes six wafer holders 42, and end

effector 20 includes a single wafer holder 52. It will be understood that each end effector may have different numbers of wafer holders within the scope of the invention. Typically, one of the end effectors includes one or more wafer holders and the other includes two or more wafer holders.

An implementation of a wafer robot in accordance with the invention is shown in FIGS. 2-6. Like elements in FIGS. 1-6 have the same reference numerals. Referring to FIG. 3, arms 14 and 22 are supported by robot body 24. Arm 14 includes an upper arm 72, connected to body 24 at a shoulder 74, and a forearm 76, connected to upper arm 72 at an elbow 78. Support block 40 is connected by a suitable bracket 80 and a wrist 82 to forearm 76. Arm 22 includes an upper arm 90 connected to body 24 at a shoulder 92 and a forearm 94 connected to upper arm 90 at an elbow 96. Support block 50 of end effector 20 is connected to forearm 94 at a wrist 98.

In operation, each of the arms 14 and 22 may rotate about the respective shoulders 74 and 92 and may change in elevation relative to body 24. The forearms 76 and 94 may rotate with respect to the elbows 78 and 96 relative to upper arms 72 and 90, respectively. Support blocks 40 and 50 may rotate relative to forearms 76 and 94 about the respective wrists 82 and 98, respectively. In the example of FIGS. 2-5, the end effectors 12 and 20 are typically moved radially with respect to a central axis 110 of body 24 during loading and unloading of wafers in a wafer carrier or processing system and are rotated about axis 110 to move from one station to another station, such as from a wafer carrier to a processing system. It will be understood that a variety of robot arm configurations may be utilized within the scope of the invention. For example, a single arm may be utilized to support and move end effectors 12 and 20, and the support blocks 40 and 50 may be connected to the arm through separate wrists.

Details of end effectors 12 and 20 are best shown in FIGS. 4 and 5. Each of the wafer holders 42, 52 may comprise a rigid metal support element 120 having a thin cross section, as shown in FIG. 4, and having a generally U-shaped configuration, as shown in FIG. 5. In particular, each wafer holder 42 may include a base 130 and arms 132 and 134 extending from base 130 to form the U-shaped configuration. Each wafer holder defines a wafer-receiving surface 140 having one or more vacuum openings.

In the example of FIGS. 4 and 5, each wafer holder 42 includes a vacuum opening 142 in base 130, a vacuum opening 144 near the end of arm 132 and a vacuum opening 146 near

the end of arm 134. Each of the vacuum openings is connected by a vacuum channel 150 to a vacuum manifold 160. Preferably, vacuum manifold 160 is located in close proximity to wafer holders 42. In a preferred embodiment, vacuum manifold 160 is located in support block 40. As described below, vacuum manifold 160 may be connected to a vacuum pump. Thus air pumped through the vacuum openings produces a suction grip on the respective wafers 44. As shown in FIG. 4, vacuum channels 150 may be formed as a recess in the underside of the respective wafer holders. The recess may be covered with a thin plate 164 to seal the respective vacuum channels 150. Each of the vacuum channels 150 may be connected, for example, by a flexible tube 166 to vacuum manifold 160.

As described below, each of the vacuum channels 150 may be connected to a vacuum sensor for sensing the presence of a wafer on the wafer holder 42. One vacuum sensor is provided for each wafer holder. The vacuum sensors may be mounted in support block 40. Vacuum sensors 170 and 172 are shown in FIG. 5. By way of example, vacuum channel 150 may be connected to vacuum sensor 170 by a flexible tube 176.

In a preferred embodiment, vacuum openings 142, 144 and 146 are located on wafer holder 42 so as to engage a semiconductor wafer near its outer periphery. In particular, vacuum openings 142, 144 and 146 may engage the wafer in an exclusion zone at the periphery of the wafer where devices are not fabricated. The exclusion zone is the outer annulus of the wafer, usually 3-5 millimeters wide, which is not productive due to process edge effects. Thus, vacuum openings 142, 144 and 146 are arc shaped. Wafer holder 42 may be provided with raised wafer retainers 180, 182 and 184 to prevent lateral movement of wafer 44 relative to wafer holder 42, such as in the event of loss of vacuum.

The wafer robot shown in FIGS. 1-6 and described above is advantageous in loading and unloading of different size wafer carriers. The configuration wherein end effector 12 has six wafer holders and end effector 20 has a single wafer holder is particularly advantageous in loading and unloading of two standardized wafer carriers used in the semiconductor fabrication industry. In particular, one standardized wafer carrier is configured for holding 25 wafers and another standardized wafer carrier is configured for holding 13 wafers. The numbers of wafer holders in the end effectors are selected to efficiently access both standardized wafer carriers. The wafer carrier having a capacity of 25 wafers may be accessed with four operations of end effector 12 and one operation of end effector 20 (6 + 6 + 6 + 6 + 1 = 25). The wafer carrier having a capacity of 13 wafers may be accessed with two

operations of end effector 12 and one operation of end effector 20 (6 + 6 + 1 = 13). It will be understood that the number of wafer holders in each end effector depends on the sizes of the wafer carriers utilized. The wafer robot may have two or more end effectors, each having one or more wafer holders.

A schematic block diagram of the vacuum gripping and sensing system of the wafer robot is shown in FIG. 6. A vacuum pump 200 is connected to vacuum manifold 160. The vacuum pump 200 pumps air from vacuum manifold 160 and thereby pumps air through each of the vacuum openings, such as vacuum opening 142, in wafer holders 42. The vacuum system provides suction gripping of wafers 44 located on the respective wafer holders. A flow restrictor 202 may be connected in each of vacuum channels 150 between the vacuum opening and vacuum manifold 160. One of the vacuum sensors 170, 172, etc. is connected to each of the vacuum channels 150 between the respective flow restrictor and the vacuum opening. The vacuum sensors sense the pressure in the respective vacuum channels and thereby sense the presence or absence of a wafer on the wafer holder. It will be understood that the pressure in the vacuum channel 150 is lower when a wafer is present on the wafer holder than when a wafer is not present. The vacuum sensor may, for example, include a diaphragm and convert movement of the diaphragm to an electrical signal. Vacuum sensors are known to those skilled in the art and are commercially available. The outputs of vacuum sensors 170, 172 etc. may be provided to a controller 210 which has a predetermined routine for responding to the presence or absence of wafers on the respective wafer holders. A vacuum sensor cable 212 (FIG. 3) may connect vacuum sensors 170, 172, etc. to controller 210 through arm 14. Vacuum sensor cable 212 may also include a conduit interconnecting vacuum manifold 160 and vacuum pump 200.

The flow restrictors 202 restrict flow of air between the vacuum opening in the wafer holder and vacuum manifold 160 so as to effectively isolate the vacuum channels 150 in each of the wafer holders from vacuum manifold 160 and permit independent wafer sensing. It will be understood that in the absence of the flow restrictors, the pressure in one vacuum channel may be affected by the pressure in another vacuum channel so that the presence or absence of a wafer may be falsely indicated. The flow restrictor 202 may have a relatively small orifice that is selected to ensure independent wafer sensing by vacuum sensors 170, 172 etc. The flow restrictors may have fixed or variable orifices. In one embodiment, the flow restrictors 202 are implemented as a section of flexible tubing having a relatively small inside

diameter.

While there have been shown and described what are at present considered the preferred embodiments of the present invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claim

s.

CLAIMS

1. A wafer robot comprising:

a batch end effector comprising:

a support block;

a vacuum manifold;

two or more wafer holders mounted to said support block, each of said wafer holders comprising a wafer support having a vacuum opening and a vacuum channel connected between said vacuum opening and said vacuum manifold; and

vacuum sensors respectively connected to each of said vacuum channels for sensing the presence or absence of a wafer on each of said wafer holders;

a vacuum pump connected to said vacuum manifold; and

an arm connected to said support block for moving said batch end effector.

2. A wafer robot as defined in claim 1 wherein said vacuum manifold is located in close proximity to said wafer holders.

3. A wafer robot as defined in claim 1 wherein said vacuum manifold is located in said support block.

4. A wafer robot as defined in claim 1 wherein said batch end effector further comprises an element defining a restriction in each of said vacuum channels for restricting gas flow from the respective vacuum opening to said vacuum manifold and wherein each of said vacuum sensors is connected to said vacuum channel between said vacuum opening and said restriction.

5. A wafer robot as defined in claim 1 wherein said batch end effector further comprises an element defining a restriction in each of said vacuum channels selected to ensure independent operation of said vacuum sensors.

6. A wafer robot as defined in claim 1 further comprising a controller for controlling

movement of said arm, said controller comprising means for receiving signals from each of said vacuum sensors for monitoring the presence of wafers on the respective wafer supports.

7. A wafer robot as defined in claim 1 wherein the vacuum opening in each of said wafer supports is located so as to engage the periphery of a wafer.

8. A wafer robot as defined in claim 1 wherein the vacuum opening in each of said wafer supports is located so as to engage an exclusion zone of a wafer positioned thereon.

9. A wafer robot as defined in claim 1 wherein each of said wafer supports has a generally U-shaped configuration and wherein said vacuum opening is located at a base of said U-shaped configuration and on sides of said U-shaped configuration so as to engage an exclusion zone of a wafer positioned thereon.

10. A wafer robot comprising:

a first end effector having a first number of one or more wafer holders;

a second end effector having a second number of one or more wafer holders;

an arm assembly for moving said first and second end effectors to perform separate operations; and

a controller for independently controlling operations by said first and second end effectors for loading or unloading a wafer carrier with one or more operations of said first end effector and one or more operations of said second end effector.

11. A wafer robot as defined in claim 10 wherein said arm assembly comprises a first arm for moving said first end effector and a second arm for moving said second end effector.

12. A wafer robot as defined in claim 10 wherein said arm assembly comprises a single arm for moving said first and second end effectors.

13. A wafer robot as defined in claim 10 wherein said first and second numbers of wafer holders are selected to permit loading and unloading of at least two different size wafer carriers with a relatively small number of operations.

14. A wafer robot as defined in claim 10 wherein said first end effector comprises six wafer holders and said second end effector comprises a single wafer holder, wherein said first and second end effectors can load and unload wafer carriers having a capacity of 25 wafers with five operations and can load and unload wafer carriers having a capacity of 13 wafers with three operations.

15. A wafer robot as defined in claim 10 wherein said first and second end effectors include means for vacuum gripping of wafers on said wafer holders.

16. A wafer robot as defined in claim 15 wherein said first and second end effectors include vacuum sensors for sensing the presence or absence of a wafer on each of said wafer holders.

17. A wafer robot comprising:

a first end effector having one or more wafer holders;

a first robot arm connected to said first end effector for moving said first end effector;

a second end effector having one or more wafer holders;

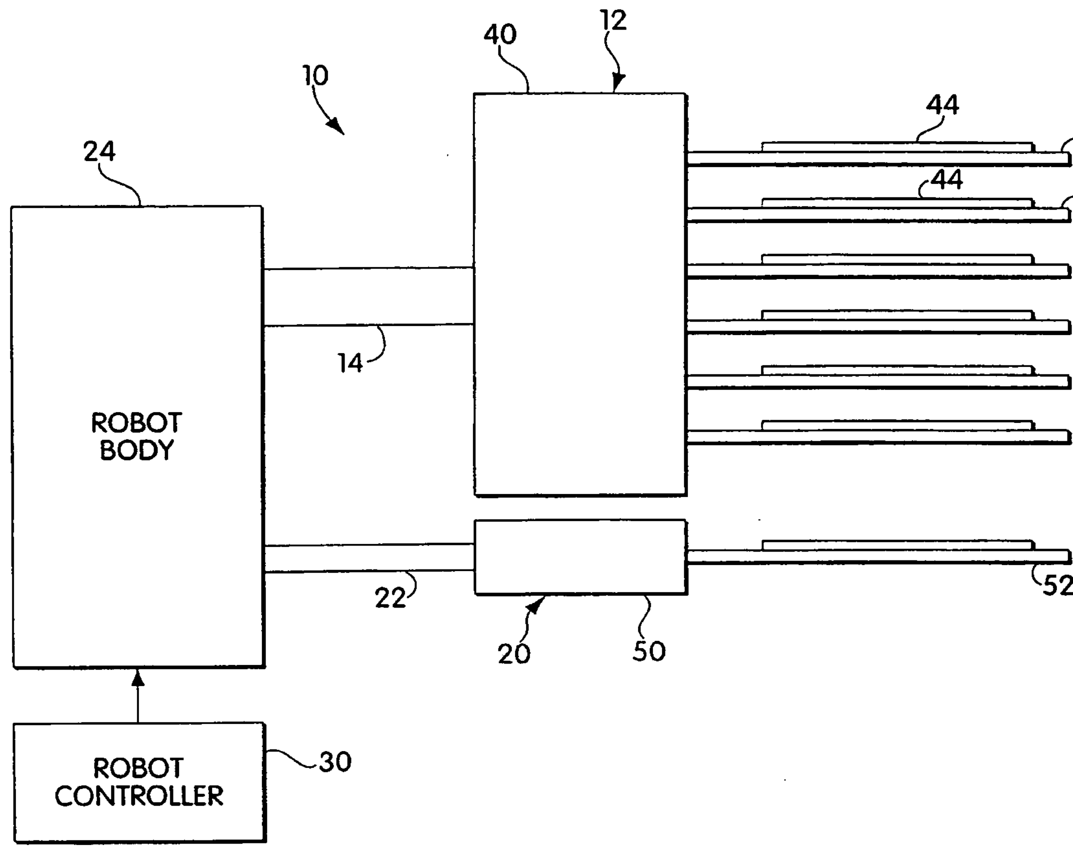
a second robot arm connected to said second end effector for moving said second end effector; and

a robot body for independently supporting said first and second robot arms; and

a controller for independently controlling operations by said first and second robot arms.

18. A wafer robot as defined in claim 17 further comprising a vacuum system for vacuum gripping wafers on each of the wafer holders of said first and second end effectors.

19. A wafer robot as defined in claim 18 wherein the wafer holders of said first and second end effectors each include a vacuum sensor for sensing the presence or absence of a wafer.



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ROBOT BODY
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ROBOT CONTROLLER
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Fig. 1

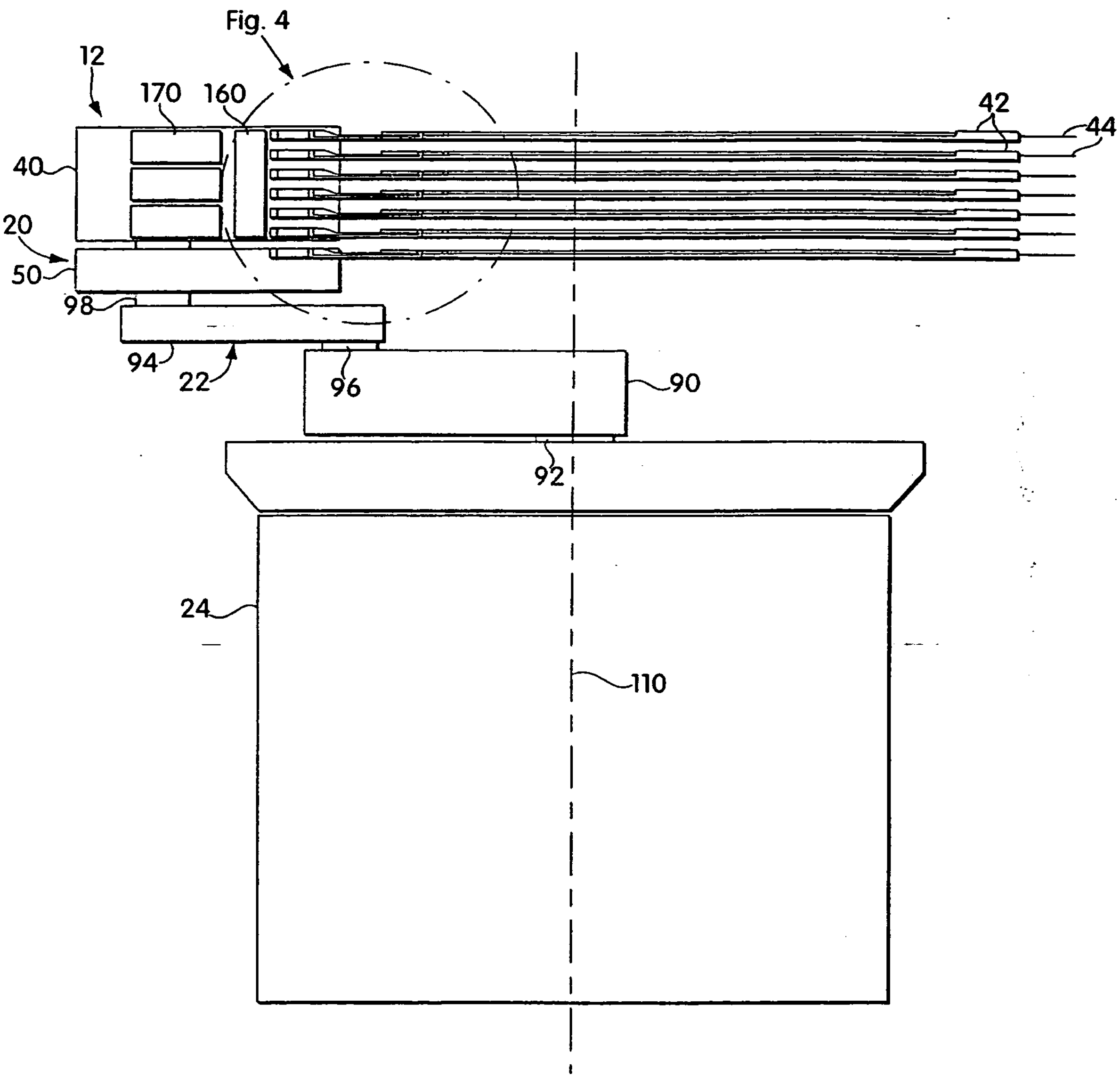

Fig. 2

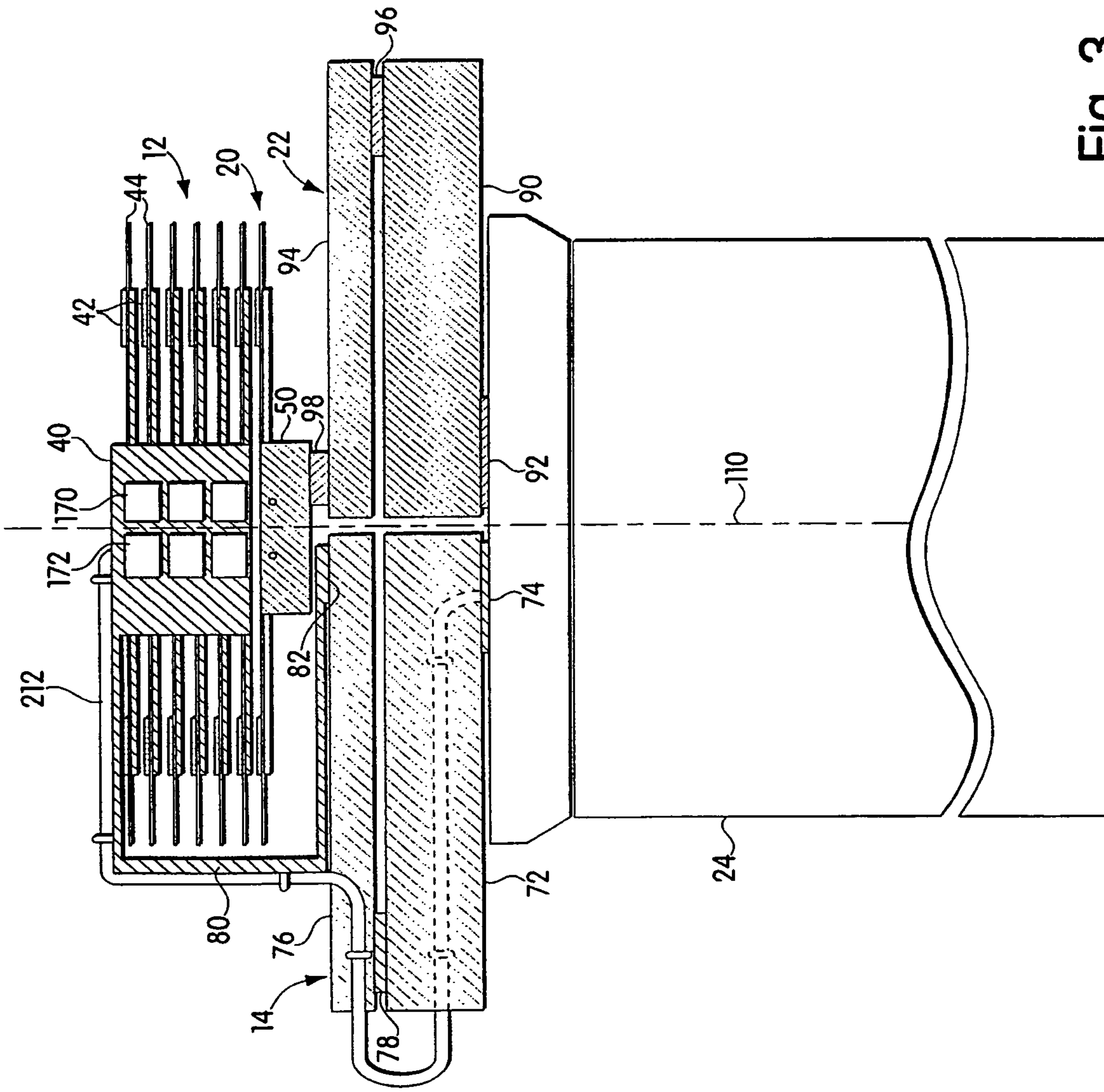
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Fig. 3

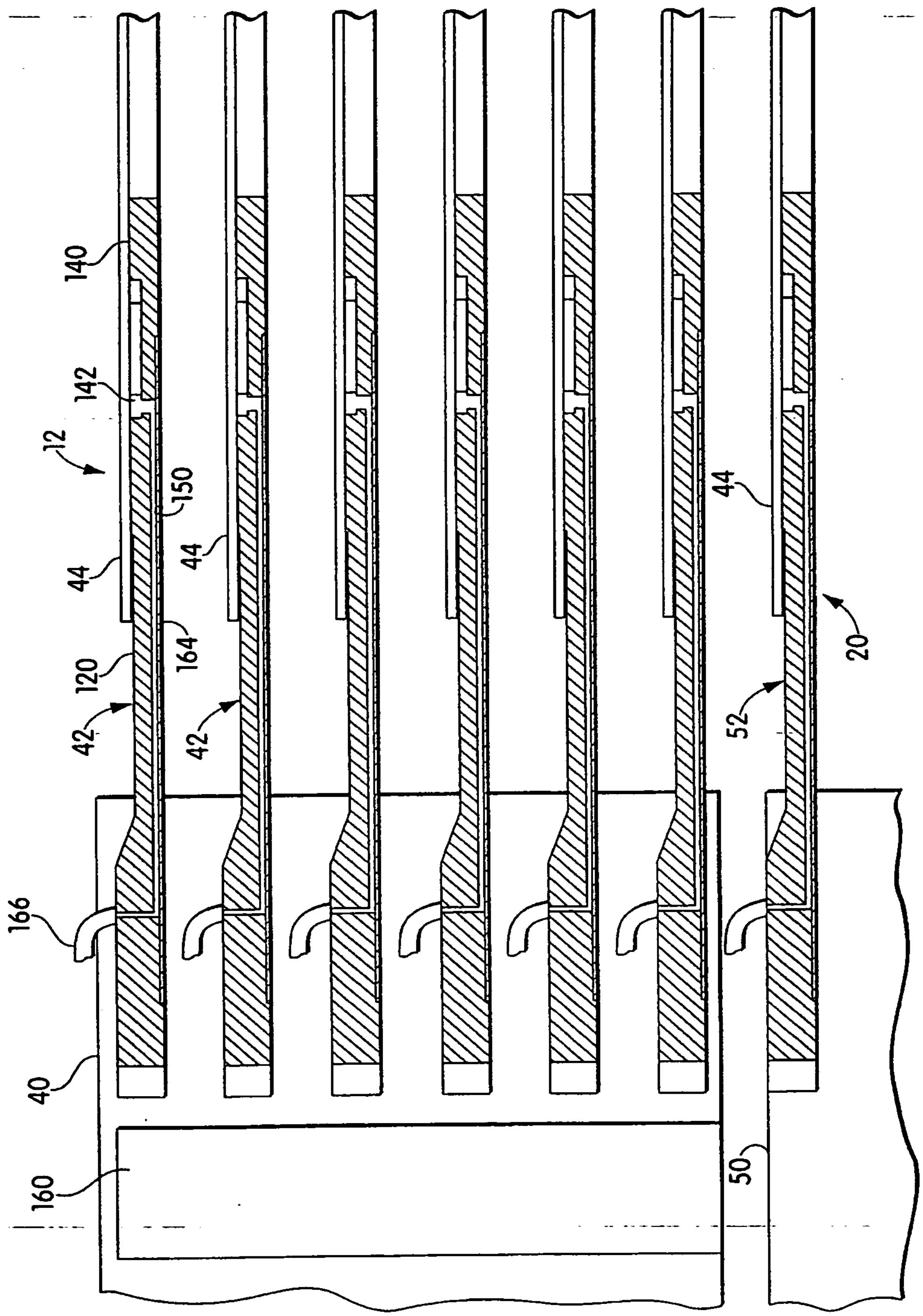

Fig. 4

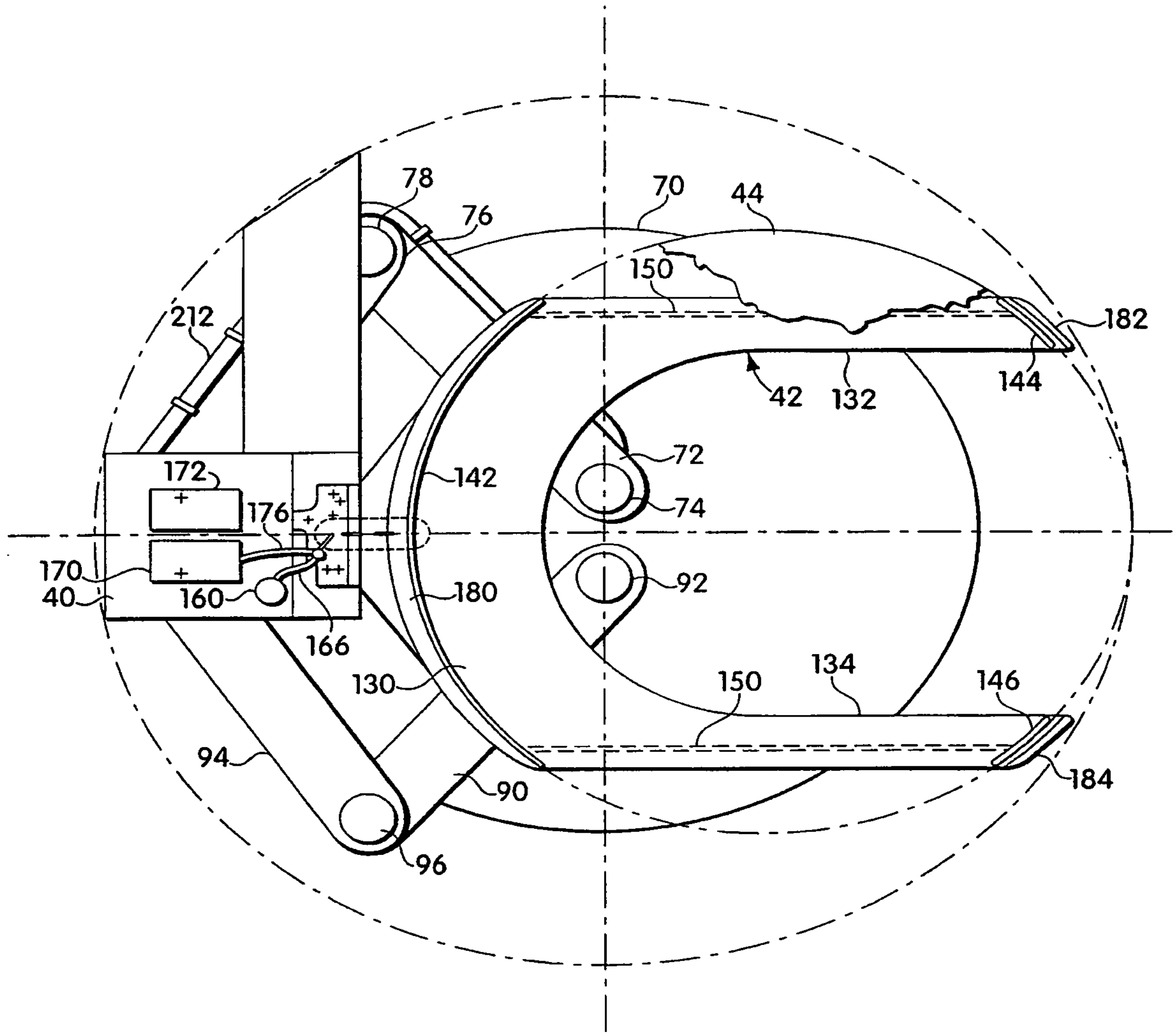
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Fig.5

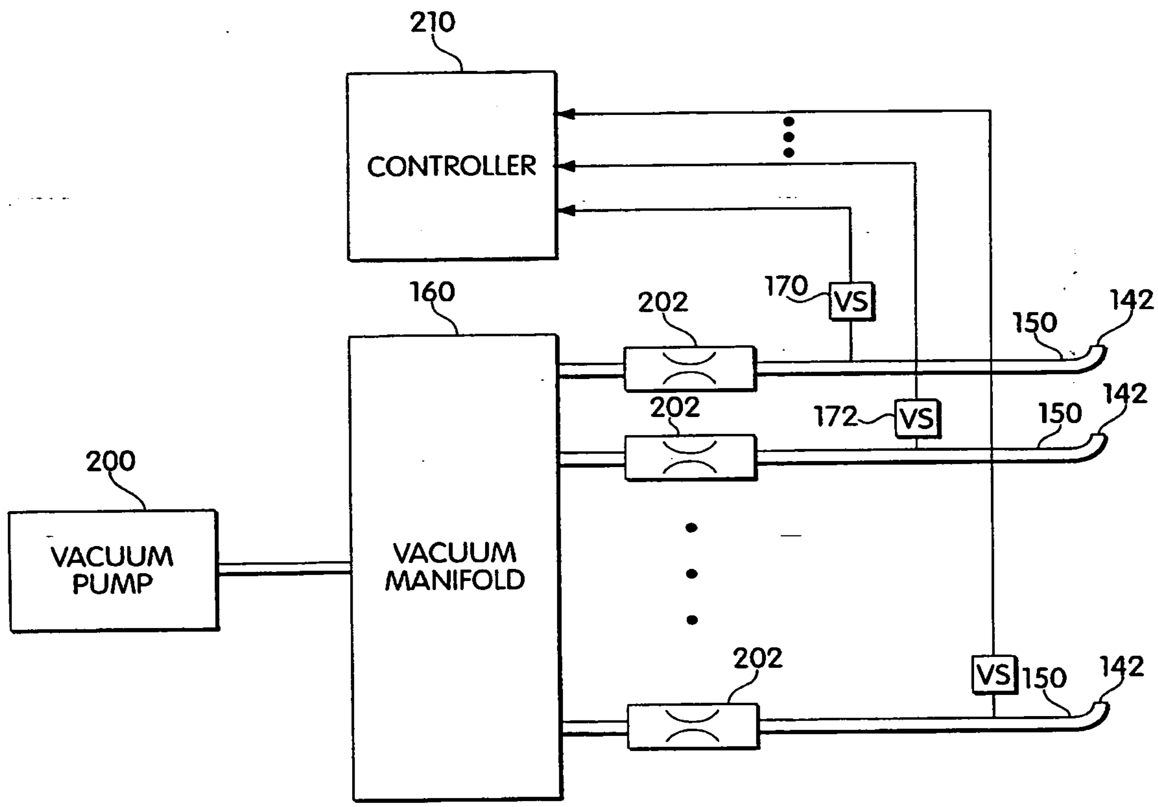
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Fig. 6

INTERNATIONAL SEARCH REPORT

International Ap. ation No
PCT/US 99/10194

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01L21/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 135 349 A (LORENZ KARL ET AL) 4 August 1992 (1992-08-04) column 5, line 20 - column 9, line 58; claims 1-4; figures 1-3,7,12,13,13A ---	1-3,6, 10,11, 15,17,18
X	US 5 584 647 A (UEHARA AKIRA ET AL) 17 December 1996 (1996-12-17) the whole document ---	10,11,17
A	US 5 664 925 A (PIPPINS MICHAEL W ET AL) 9 September 1997 (1997-09-09) cited in the application the whole document --- -/--	1,10,17

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 August 1999	07/09/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Visentin, A

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/10194

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2 590 879 A (AMERICAN TELEPHONE & TELEGRAPH) 5 June 1987 (1987-06-05) page 4, line 3 - page 9, line 32; claims 14-21; figures 1-3,6	1,6,10, 15,17,18
A	FR 2 664 526 A (VILLEJUIF ETUDES IND) 17 January 1992 (1992-01-17) the whole document	1,7-9
A	EP 0 634 787 A (APPLIED MATERIALS INC) 18 January 1995 (1995-01-18) column 8, line 41 - column 14, line 58; figures 1-12	1-9
A	EP 0 669 642 A (APPLIED MATERIALS INC) 30 August 1995 (1995-08-30)	

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 99/10194

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5135349 A	04-08-1992	JP 2086375 C	23-08-1996
		JP 4065148 A	02-03-1992
		JP 7109854 B	22-11-1995
US 5584647 A	17-12-1996	JP 2083182 A	23-03-1990
		JP 2111560 C	21-11-1996
		JP 8025151 B	13-03-1996
		US 5083896 A	28-01-1992
US 5664925 A	09-09-1997	AU 6408996 A	05-02-1997
		CN 1195332 A	07-10-1998
		EP 0886617 A	30-12-1998
		WO 9702199 A	23-01-1997
FR 2590879 A	05-06-1987	DE 3639991 A	04-06-1987
		JP 62188336 A	17-08-1987
FR 2664526 A	17-01-1992	NONE	
EP 0634787 A	18-01-1995	US 5697748 A	16-12-1997
		DE 69402918 D	05-06-1997
		DE 69402918 T	14-08-1997
		EP 0734056 A	25-09-1996
		JP 7058183 A	03-03-1997
		US 5556147 A	17-09-1996
		US 5570994 A	05-11-1996
		US 5636964 A	10-06-1997
EP 0669642 A	30-08-1995	US 5643366 A	01-07-1997
		JP 7297262 A	10-11-1995